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N. G. F. Performance Grease Tests

(Grease Torque Machine)

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1. Introduction

The advent of the war marked a complete change in Naval Ordnance lubrication practice. Prior to this time, conditions had been rather favorable for obtaining satisfactory operation of Naval Ordnance equipment in that most of the Fleet's operations were conducted in climates which were not subject to adverse temperatures. However, conditions soon changed. One of the earliest trouble reports was received from a petty officer in charge of an armed guard crew of a merchantman on the Murmansk convoy. This officer reported that under severe cold weather conditions, 3"/50 caliber and 4"/50 caliber gun mounts became inoperable due to congealing of the lubricants and to freezing of spray which collected on greased mating parts. It became necessary for the crew to take the following steps to keep their gun mounts in operation. All working parts were cleaned of any excess grease and then coated with ligh mineral oil (S.A.E. 10) which had been heated to 180°F. However, these operations were unfavorable in that they left the mounts subject to corrosion and in addition required repetition every two or three hours making a practically continuous schedule. Also, it was necessary to train and elevate the gun mounts throughout their entire arcs after each application of heated lubricant and more frequently if conditions required it.

Accordingly, it became the task of the Naval Gun Factory to alleviate these conditions as much as possible. It was decided that the course to follow would be to obtain a general purpose grease which would prove suitable for allowing free operation of gun mounts under any conditions which might prevail aboard ship. The result of this conclusion was the drafting of Ordnance Specification 1350, Bearing Grease for General Use in Naval Ordnance.

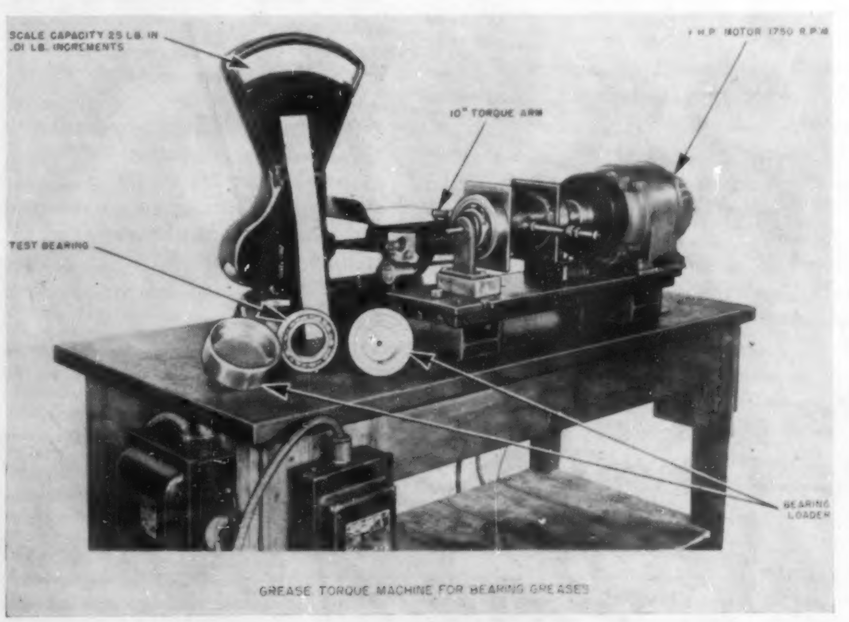
In preparing this specification, it became necessary to incorporate a cold temperature requirement capable of reproducibility and particularly adapted to the needs of Naval Ordnance. The answer to this problem evolved as the performance tests made on the N.G.F. Grease Torque Machine.

2. Description of N.G.F. Grease Torque Machine

It was decided to construct as simple a machine as possible in order to insure relative ease of manufacturing duplication and still provide a yardstick for measuring shear resistance of various lubricating greases.

Accordingly, a small dynamometer type housing was constructed so as to give a direct torque reading from the pressure of the housing arm on the scale. An assembled view of the complete torque machine is shown on the print of N.G.F. negative 27892, attached.

The N.G.F. Grease Torque Machine consists essentially of the dynamometer type housing shown on the attached negative which is directly coupled from the driving shaft to the 1750 r. p. m. driving motor,



GREASE TORQUE MACHINE FOR BEARING GREASES

with the shaft ends mounted in the small pillow blocks and the housing supported on the shaft by the two test bearings. The standard test bearings used are McGill No. 214, Single Row, 10 Balls, Bore Size 2".7559 and 4".9213 O. D.

The test bearings are loaded by a standard procedure utilizing the N.G.F. Bearing Loader, shown on the attached negative, which is a modification of the Navy Grease Packer. This loader consists of pieces 3, 4 and 5 of attached drawing 239902. The test bearing is fitted into the cup shaped base, piece 3, and the cap, piece 4, screwed down tightly into the base. The adapter, piece 5, is screwed into the cap so as to permit attachment of a screw type grease gun full of the test grease for loading the bearing. This arrangement permits the grease to be forced from the gun through the bearing cap and the pilot contained thereon so as to extrude into the base of the packer and then through the ball races evenly until excess grease appears from the twelve 1/32" bleed holes in the packer. The procedure is continued until no more air bubbles are observed in the grease coming from the bleed holes, thus insuring even distribution of the grease throughout the bearing races and no possibility of any entrapped air being contained therein. Upon completion of this process, the bearing packer is disassembled utilizing the flats on the base of the packer and the hexagonal head on the packer cap for unscrewing purposes. The bearing is then removed from the packer base and the grease scraped off flush by a grease spatula held vertical to the bearing face so as to insure complete filling with no overflow of grease from the bearing for each test, thus providing standardized packing.

Two test bearings packed in the above manner are then placed in the housing, piece 1 of drawing 239901. The attached drawings show details for assembly of this equipment both as a grease testing machine and an oil seal testing machine; however, for the purposes of this discussion, only those details concerning the grease torque machine will be covered. The original setup of the housing is shown in the assembly view of drawing 239902. Since this time, the method of holding the test bearings in place has been modified as it was found unsatisfactory for slippage reasons to hold the test bearings with the locknuts. Later modifications provide a smaller diameter on the shaft where the screw threads are shown so as to permit the sliding on of a circular flat disc which is pressed tightly against the outer face of the inner bearing race by bolting the plate directly into the shaft itself. This prevents any slippage of the inner race of the bearing. The complete housing with the test bearings and driving shaft assembled therein is supported on the two small pillow blocks shown in the assembled view and on the attached negative. The driving shaft is supported in the pillow blocks by two radial single row ball bearings. Bore Size ".5906 and 1".3780 O.D.. One end of the housing shaft is directly coupled to the driving shaft of a 1 hp. 1750 r.p.m. single phase induction motor. Different speeds may be obtained by utilizing other speed motors or by pulley connections between the motor shaft and the housing shaft. However, for these grease tests, the 1750 r.p.m. constant speed has been standardized as the majority of Naval Ordnance power drives are operated by 1750 r.p.m. driving motors. The housing contains two lever arms, each on opposite sides, which measure 10" from the housing center to the knife edge on the end. In addition, each arm supports a balance weight which may be adjusted so as to provide for perfect balancing of the housing. The scale reading is obtained from the pressure of the knife edge on the platform scale, shown by the attached negative, which gives readings in .01 lb. increments up to 25 lb. capacity. The torque measurement is determined as the product of the scale reading by the 10" lever arm length.

3. Test Procedure

In the original development of the test procedure, attempts were made to standardize the test evaluation by utilizing the same weight of different types of greases for packing the bearings. It was found in the main that over an extended running time of one half hour, approximately one half of the grease was thrown out of the bearing. After considerable experimentation, it was concluded that the most satisfactory way of packing the bearings, especially from a standardization viewpoint, was by volume rather than weight of grease, and that the method aforementioned was satisfactory for producing identical bearing packings for each test.

Another relative measurement for evaluation of greases which was considered and experimented upon was the determination of temperature rise during the course of the running of the test. To obtain these results, thermocouples were placed through the bearing retainers so as to touch upon the outer races of the test bearings. Temperature rise readings by this method were taken for a series of greases of approximately the same nature which were being tested under O.S. 1350. Mostly, these readings did not show enough difference in temperature rise for the various greases so as to formulate any particular indicative value over a short running time. This was especially true of torque tests conducted on various greases at room temperature. It was, therefore, concluded to drop these temperature rise readings and to maintain only the torque readings as comparative values on the evaluation of different greases.

The temperatures used for conducting these grease torque tests are, of course, governed by actual conditions experienced aboard Naval vessels. Reports received from the Fleet to date have indicated that the lowest temperatures encountered have been —10°F. when lying close in shore at severe Arctic temperatures, and in the main, not lower than 0°F. when operating on the open sea. It was, therefore, decided to conduct these grease torque tests at ambient temperatures of 0°F. and 70°F. The method that is used at the Naval Gun Factory for obtaining these test temperatures is to place the complete machine in the desired ambient temperature. The cold test room is utilized for obtaining the 0°F. condition. This temperature room, being large enough to hold complete Naval gun mounts, will easily accommodate the torque test machine and the operator. Experimentation has proven that upon moving the torque test machine from room temperature to 0°F. ambient temperature, a period of approximately four hours is required to stabilize the complete machine at 0°F. Therefore, the procedure for each cold temperature torque test is to allow the torque machine to stand idle at 0°F. for four hours before operating. The complete torque test equipment may also be assembled as a portable unit and placed in a small cold temperature chamber for conducting torque tests when the temperature room is not available. The space required for the complete unit is 24 inches by 36 inches by 30 inches.

Another test condition which had to be standardized was the length of running time. A series of tests was made on various greases using running times varying from five minutes to thirty minutes. It was found throughout these runs that the majority of greases of the type which would be subjected to these torque tests obtained a minimum running torque value after five minutes operation. This value maintained itself fairly steady up to the end of the thirty-minute period. It was, therefore, concluded that the standard running time for each test would be five minutes. As it was contemplated that there would be a considerable number of greases to be tested on this machine, the time was held to a minimum.

This scale which has been adopted for these torque tests has a maximum dial reading of 5 lbs. graduated in .01 lb. increments. However, the maximum load read-

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ing obtainable is 25 lbs. This is obtained by the use of two 10 lb. adjustments on horizontal bars which may be placed at any position in one lb. increments. Therefore, in the case of greases which will give torque values in excess of 50 lb. in., it becomes necessary to make adjustments before conducting the tests. It is the duty of the operator by visual inspection to arrive at an approximate torque reasoning before operating, and adjust the scale accordingly. When testing greases under definite specification values, it is the practice to adjust the scale so that the maximum attainable reading will be approximately 20 or 30 lb. in. more than the specification requirements, thus insuring a definite indication of failure under that particular requirement. For these reasons, some values reported will be expressed as a torque reading with a plus sign. This indicates that the scale needle reached the maximum for which adjustment had been made for this particular run.

In the original testing, it was decided to arrive at an indication of how much of the torque value obtained was directly attributable to the grease in the test bearings. Accordingly, the torque test machine was set up for a room temperature run with the bearings in place and completely clean so as to leave no trace of any lubricant on the balls or races. The values obtained from this particular test were a starting torque of one lb. in. and a minimum running torque of .5 lb. in. attained within one minute after starting which increased very slightly over a 30-minute run to a maximum of .8 lb. in. As most of the greases tested to date under Ordnance Specifications have given starting torque values in the neighborhood of at least 10 lb. in., even at room temperature, it is obvious that the torque obtained from the machine itself may be neglected.

The starting torque for these tests is obtained by watching the maximum deflection of the scale needle and catching the momentary pause at the end of the stroke by visual examination. Some greases, possibly because of rougher consistencies, will provide erratic readings during the course of the run with the needle jumping from high to low values and vice versa throughout this period. However, most of the greases will have obtained a fairly steady reading by the end of the five minute running period, and therefore, it is deemed satisfactory to take the measurement of running torque at this time.

There have been several types of torque test apparatus developed for evaluating various greases, and there have been some difficulties encountered in obtaining reproducible results. Therefore, it was the policy of the Naval Gun Factory to make the machine and also the test method as simple as possible and yet provide a suitable yardstick for obtaining comparative values of different greases. The Naval Gun Factory has been very successful in obtaining fairly reproducible results on this particular machine even when using different operators. The following table lists several greases and the results of their original and check runs for obtaining reproducibility, some of the tests for which were made by the same operator and some by different operators. These tests were all conducted at 0°F. as the maximum torque values are naturally obtained at this temperature.

Grease	Original Tests Starting Torque lb. in.	Original Tests Running Torque lb. in.	Check Tests Starting Torque lb. in.	Check Tests Running Torque lb. in.	Deviation from Original Test Starting Torque %	Deviation from Original Test Running Torque %
A	70.0	17.0	74.6	17.4	6.6	2.4
B	70.0	18.4	74.2	18.1	6.0	1.6
C	75+	17.6	75+	17.4	....	1.1
D*	34.7	12.2	31.8	12.0	8.3	1.6
E*	113.4	18.2	109.2	17.8	3.7	2.2
F**	41.2	11.0	48.0	13.2	16.5	20.0

*Check tests performed four months after original tests.

**Check tests performed two years after original tests.

In addition, results have been reported from one other laboratory to date on a similar machine manufactured from the same drawings. These results check very closely with the Naval Gun Factory runs on the same grease, especially considering the fact that the machines were produced by different manufacturers and controlled by different operators. The comparison of results is as follows:

Grease	N.G.F. Tests Starting Torque lb. in.	N.G.F. Tests Running Torque lb. in.	Laboratory No. 2 Tests Starting Torque lb. in.	Laboratory No. 2 Tests Running Torque lb. in.	Deviation from N.G.F. Test Starting Torque %	Deviation from N.G.F. Test Running Torque %
G	44.5	9.6	40	9	10.1	6.2

From the above tables, it appears conclusive that these torque tests are as reproducible as may be expected of any grease test of this type.

There has been some difficulty encountered in correlating results obtained from the Naval Gun Factory Grease Torque Machine with those obtained from other torque machines. This is particularly true of the torque test specified in AN-G-3, Low Temperature Lubricating Grease. Several greases which have satisfactorily passed the AN-G-3 torque test at −67°F. have fallen down on the 0°F. torque requirements under O.S. 1350, Bearing Grease for General Use in Naval Ordnance, when tested in the N.G.F. Grease Torque Machine. This is believed to be attributable to the slow speed attained on the AN-G-3 torque test device while the N.G.F. Grease Torque Machine is operated at 1750 r.p.m. bearing speed.

Another test which has proven quite satisfactory for Naval Ordnance needs and that is performed on the Naval Gun Factory Grease Torque Machine is the water saturated torque test specified in Ordnance Specification 1350. The process in this case is to mix as much water with the grease sample as it will absorb and then to submit this mixture to the regular 0°F. torque test. The reason for adapting this particular test is that aboard Naval vessels, gun mounts are continually subjected to the wash of sea water, especially in heavy seas. This is particularly true of the No. 1 for-

ward mount on many Naval vessels. Here the roller paths and the entire lower part of the mount are often awash from sea water even while operating. This would cause the mixture described above to be formed in the actual gun mount aboard ship. Accordingly, it is deemed advisable to determine the performance characteristics of Ordnance greases under these particular conditions.

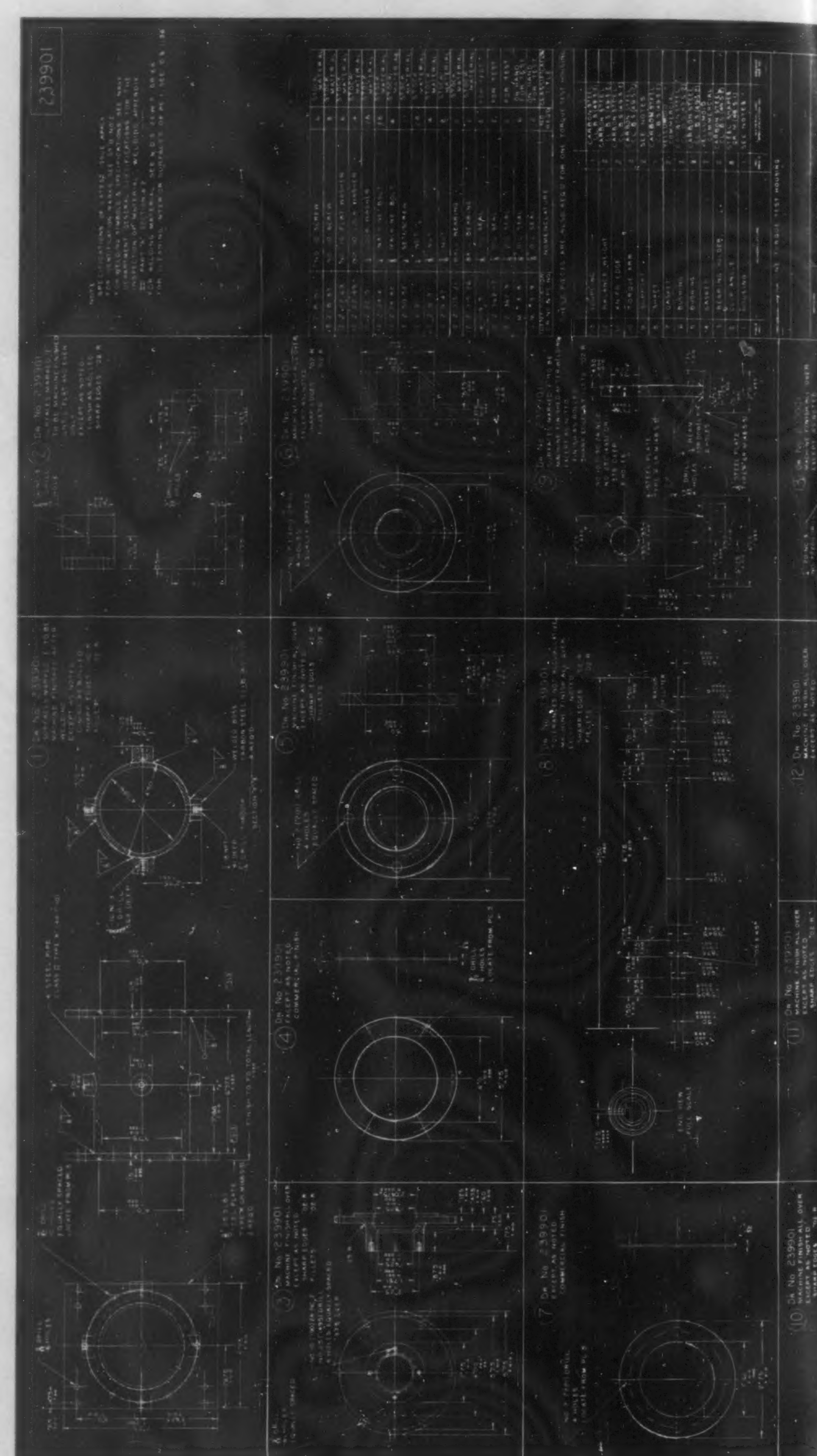
The N.G.F. Grease Torque Machine may also be adapted for determining comparisons of the same grease when subjected to other conditions. One example of this which has been tried to demonstrate the effect of continued heat on a grease sample follows: A grease which had a starting torque value of 31 lb. in. at 0°F., when received in its original state, was subjected to 180°F. for 24 hours and then re-submitted to the 0°F. torque test. The result obtained was 70+lb. in. starting torque, thus demonstrating how much effect the prolonged high temperature condition had upon this particular grease.

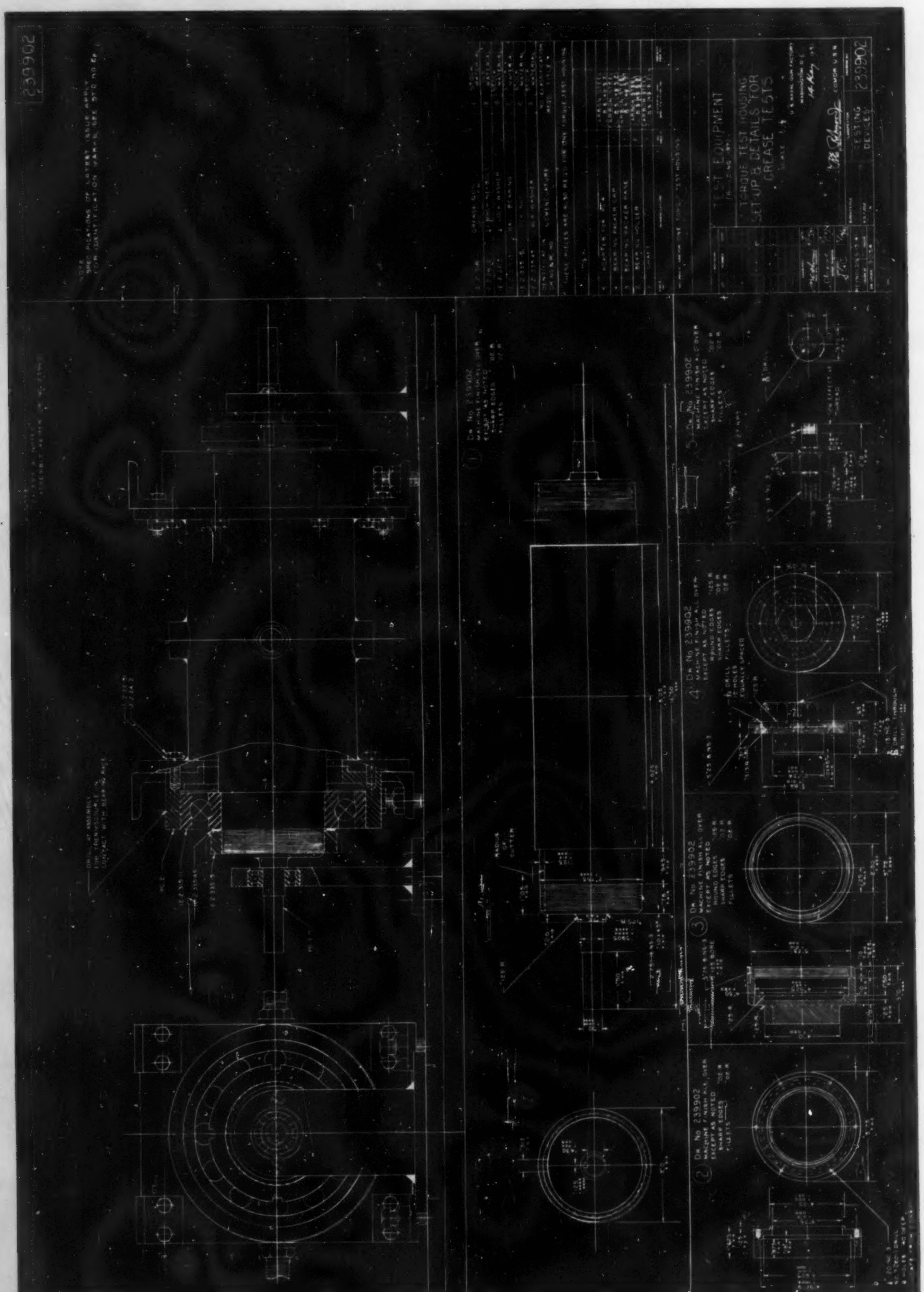
Two other differences which have been demonstrated on this torque machine are the following: In the first case, a small amount of polar inhibitor was added to a mineral lubricating grease. The results obtained on the uninhibited grease in the 0°F. torque test were 28.4 lb. in. starting torque and 11.0 lb. in. running torque. After placing the inhibitor in the grease the starting torque was 31 lb. in. and the running torque 12.2 lb. in. When putting a hypoid additive in the uninhibited grease, results obtained were 50+ lb. in. starting torque and 14.0. in. running torque.

This machine has also been tried for demonstrating the resistance of various oils to the rotation of ball bearings. However, when using oils it is difficult to obtain reproducible conditions of coating the bearings due to the difference in the lubricating films of various oils and also their tendency to run off of bearing surfaces.

4. SUMMARY

A testing device has been described which was developed at the Naval Gun Factory for evaluating various lubricating greases. This machine has proven to be capable of good reproducibility at both normal and low temperatures. It may also be operated at various speeds. Results have shown that the method of packing the test bearings by volume, as set forth, gives reproducible results. Readings obtained from dry test bearings show the torque produced by the machine to be small in comparison to the actual grease torque values. This machine has also been used for evaluating the effect of high temperatures on grease and the effect of certain additives on the torque value of the basic grease.

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